91602
new 82-10

To: D.A. Lee
Manager
Safety Services Dept
Health & Safety Division, H2A20

ontario hydro
research division

COMPLIMENTARY COPY
Please Credit Ontario Hydro Research if
Reproduced in Whole or in Part

A MAGNETIC FIELD EXPOSURE MONITOR

J.C. Kuurstra

A pocket-sized Magnetic Field Exposure Monitor (MFEM) has been developed to measure and record the level of 60-Hz magnetic fields to which electrical utility workers are exposed. It can monitor the magnetic field strength for periods of up to one work week, storing the average magnetic field level every minute. The data can then be transferred to a computer for display, analysis and long term storage.

1.0 INTRODUCTION

The Magnetic Field Exposure Monitor (MFEM), shown in Figure 1, is a pocket-sized, battery powered device that measures and records the level of ambient 60-Hz magnetic fields. It stores the average magnetic field every minute for periods of up to 136 hours, or about 5.7 days. The recorded data can be downloaded to an IBM PC or compatible computer, through a special computer interface adapter, for subsequent display, analysis and long term storage.

The MFEM was designed for use in a field study undertaken by the Health and Safety Division to determine the level of magnetic fields to which electrical utility workers are exposed. Development of this device was carried out by the Electrical Research Department and co-funded by the Research Division and Health and Safety Division.

This report provides a general description of the monitor and how it operates. Engineering details are given in reference/1/.

2.0 GENERAL DESCRIPTION

The Magnetic Field Exposure Monitor consists of an electronic circuit board, a magnetic field strength sensing coil and a battery. These are all housed in an aluminum box, which is small and light enough to be carried in a worker's shirt pocket.

job	file	date	report no.
11-140	817.34	February 24, 1987	87-50-K

The MFEM operates by sampling the magnetic field strength every 16 seconds and storing the average level every minute, for periods of up to 136 hours. The data is stored in a circular queue, so that for recording periods longer than 136 hours the MFEM constantly retains the most recent 136 hours' data. By means of the special interface adapter, the MFEM can be connected to an IBM PC or compatible to enable the downloading of data, and also to allow the MFEM's internal real-time clock to be set.

A typical data gathering session proceeds as follows. First, before the MFEM is issued to the field, its real-time clock is set by connecting it to a computer via the computer interface adapter, and executing the software supplied with the adapter. Having set the time, the device is then taken out to the field for a recording session of up to 136 hours. (Longer recording sessions can be used but at any given time only the most recent 136 hours' data is retained.) At the end of the recording session, the MFEM is once again connected to the computer and the memory contents are transferred for display and further analysis. When connected to the computer interface, the MFEM's battery life status can be checked. (The battery life is typically about four months under normal conditions.)

3.0 OPERATING PRINCIPLES

The MFEM circuitry consists of a signal conditioning circuit, an 8-bit analog-to-digital converter, a crystal-controlled real-time clock, a non-volatile memory and a single-chip microcomputer. The circuitry is based on an adaptation of the circuitry used in the Electronic Recording Ammeter (ERA), a device previously developed by the Research Division for monitoring current in distribution lines/2/. For the present application, a special input circuit was added to accept the signal from the magnetic sensing coil.

The sensing coil consists of a single, tapped, multi-turn coil installed along the inside perimeter of the box housing the MFEM. By selecting either the whole coil, or just the part on one side of the tap, two ranges are available, namely 0.1 and 0.5 millitesla nominal full scale. In either case, the signal induced in the coil by the ambient 60-Hz magnetic field is filtered and rectified to produce a 0-5 V dc signal that can be sampled by the analog-to-digital converter (ADC). The output of the ADC is a number ranging from 0-255, giving a resolution (least significant bit) of 0.4 microtesla on the 0.1 millitesla range, or 2.0 microtesla on the 0.5 millitesla range.

Every 16 seconds, based on a signal derived from the real-time clock, the microcomputer instructs the ADC to digitize the mag-

netic field signal. These 16-second samples are averaged over one minute intervals and then stored in the memory, still as numbers in the range 0-255. The memory size is sufficient to store 8182 samples, or 136 hours of data.

The data can be transferred to the processing computer through a special computer interface which temporarily supplies power to the MFEM and matches the serial communication signals to the computer. The output of the MFEM is an ASCII message consisting of a one-line header followed by the field strength data in reverse chronological order (ie, the first number transferred is the average field strength of the last complete one-minute interval preceeding the transfer). The header contains the serial number of the MFEM as well as the real time and date at the time of the transfer. This time and date can be used by the computer to determine a time stamp for each item of data.

The transfer of data to the computer, and storage on the computer's disk, can be done using a standard PC communication software package. Detailed instructions on how to use the interface adapter to connect the MFEM to the computer are given in reference/2/.

4. SPECIFICATIONS

4.1 MFEM

Magnetic Field Level Ranges (nominal):	Two (selected by internal jumper) - 0.0 to 0.1 millitesla (1 gauss) - 0.0 to 0.5 millitesla (5 gauss)
Nature of Recorded Data:	The data stored is the average magnetic field strength, expressed as a number in the range 0 to 255, for each 1 minute period based on samples taken every 16 seconds.
Resolution:	0.1 mT range: 0.4 microtesla (4.0 milligauss) 0.5 mT range: 2.0 microtesla (20 milligauss)
Accuracy:	0.1 mT range: Error is < (5% of reading ± 0.4 microtesla) 0.5 mT range: Error is < (5% of reading ± 2.0 microtesla)
Effect of Field Level Exceeding Full Scale:	Reading set to full scale value

Data Output:	Serial line interface: RS232, 9600 baud (needs special interface box).
Time to Transfer ERA Data to Computer:	Approximately 45 seconds.
Battery Type:	Two 3.6 V lithium batteries size 1/2 AA.
Battery Life:	Typical: 4 months Minimum: 3 months
Memory Size:	8k bytes. Will store 136 hours of data (= 5 days, 16 hours). New data will overwrite oldest, so that at any given time the most recent 136 hours of data are retained.
Memory Type:	CMOS RAM (acts as non-volatile memory by virture of the continuously connected battery).
Timing:	Real-time clock derived from crystal oscillator. Maximum time error is 1 minute per 2 weeks over specified temperature range.
Operating Temperature Range:	-40°C to +55°C
Weight:	0.26 kg
Dimensions:	7.5 x 13 x 2 cm

4.2 Interface Adapter

Power Supply	7.5 Vdc, 100 mA (via a 115 V ac adapter)
Maximum Data Rate:	9600 baud

Battery Check Voltage Level:	Factory set to 6.95 V in the 'SUMMER USE' switch position and 7.80 V in the 'WINTER USE' switch position. Battery to be at room temperature for the test. (For the MFEM, use 'SUMMER USE' switch position for all operating temperatures.).
Dimensions:	6.5 x 12 x 4 cm

5.0 STATUS

Six Magnetic Field Exposure Monitors have been assembled and are currently being used in a field study carried out by Health and Safety Division.

Approved:

A.F. Baljet
Manager
Electrical Research Department

Submitted:

J.C. Kuurstra
Engineer
Electronics & Instrumentation Section

Reviewed:

J.D.A. Griffin
Unit Head - Electronics
Electronics & Instrumentation Section

JCK:lAg

REFERENCES

1. A Magnetic Field Exposure Monitor: Engineering Details, Ontario Hydro Report No E87-7-K.

2. Electronic Recording Ammeter Instruction Manual, Ontario Hydro Report No 84-1-K.

Figure 1

Magnetic Field Exposure Monitor

DISTRIBUTION LIST

Mr. D.A. Lee	Health & Safety Div, H2A20
Mr. M.L. Walsh	Health & Safety Div, Pickering
Mr. D. Agnew	Health & Safety Div, Pickering
Mr. D.J. Gorman	Health & Safety Div, Pickering
Mr. G. Ellis	Marketing Operations, C26 A6
Mr. G.E. Fraser	Distribution Systems, U6A6
Mr. W.R. Collard	Design & Development Div-Gen, H12A27
Mr. R.M. Burnard	Design & Development Div-Gen, H13A13
Mr. E.J. Gooch	Design & Development Div-Gen, H10A27
Mr. C.P. Khera	Information Services Div, M3A1
Mr. K. Stait-Gardner	Information Services Div, M2A9
Mr. H.C. Palmer	Market Services & Develop Div, C25A6
Dr. R.C. Oberth	New Business Ventures Div, C27F2
Mr. B.K. LeReverend	Power System Operations Div, A6A6
Mr. J.S. Hartill	Transmission Operations Div, U10A5
Mr. R.R. Urquhart	Transmission Operations Div, U9B1
Dr. N. Anyas-Weiss	Electrical Research
Dr. K.E. Donnelly	Electrical Research
Dr. S.M. Harvey	Electrical Research
Mr. J.M. Bell	Electrical Research
Mr. J.N. Edgar	Electrical Research
Dr. G.L. Ford	Electrical Research
Mr. C. Erven	Electrical Research
Mr. D.C. Lee	Electrical Research
Mr. R.D. Brown	Electrical Research
Mr. J.C. Kuurstra	Electrical Research

Editorial Section (2)
Public Reference Centre
Office Copies (3)
Extra Copies (3)